

Final Technical Report

1 June 1994 - 31 October 2001

"Louisiana NASA EPSCoR Project"

NASA Cooperative Agreements
NCCW-0059 (6/1/94 - 5/31/97 NCE)
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SUMMARY

In 1994, the National Aeronautics and Space Administration issued a Cooperative Agreement (CA) to the State of Louisiana, through the Louisiana Board of Regents (BOR), for the performance of scientific research under the Experimental Program to Stimulate Competitive Research (EPSCoR) Project. Originally constructed as a three-year program with an optional two-year follow on, this federal-state partnership culminated on 31 October 2001, including two CA extensions. The total value of the project reached \$3.3M in NASA funding, matched by \$2.75M in BOR funds, and supplemented by several million dollars in institutional contributions. Three Research Clusters comprised the state-wide research effort coupled with scientific/technical management and a teacher involvement component.

The three research clusters addressed the Enterprises of Space Science, Earth Science and Aerospace Technology with research in High Energy Astrophysics, the Global Carbon Cycle, and Propulsion. Ten universities, over two dozen faculty, over 150 students and numerous support personnel were involved. All of the scientific and technical objectives were met or exceeded.

This Cooperative Agreement was very successful in developing research capability in Louisiana. The three clusters produced over 75 publications in refereed journals, 130 articles in conference proceedings, over 100 presentations, and one patent. Forty-two advanced degrees were earned by MS or PhD students and close to a hundred undergraduate students were directly involved in the research.

In aggregate, the clusters generated about \$18M in outside support, better than a 2:1 return on investment (better than 5:1 considering only the NASA investment). Moreover, two of the clusters have advanced to the level of applying for major NSF research center designation.

This project was a trial of the model of building research infrastructure through mentoring. While not completely successful, the results at the smaller institutions were, none the less, positive. Faculty were engaged in major research and involved their students. Administrations improved their capabilities to handle grants and contracts. Faculty release time was granted, research space was provided and, in some cases, equipment was made available for the research. Some of the faculty at these schools have remained involved in research and/or formed collaborations for new endeavors, demonstrating that the mentoring model can be successful.

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Acknowledgements

Bringing a project like NASA EPSCoR to fruition requires the coordinated activities of many people. It is with deep appreciation that we acknowledge the outstanding contribution of the following organizations to the success of this project: the Louisiana Board of Regents Staff, Louisiana State University, the research cluster Principal Investigators, and the Co-Investigators and their respective institutions. Also deeply appreciated is the evaluation and recommendation assistance of the out of state technical evaluators and the staff at NASA Headquarters. It is through the careful cooperation of this extended team that the NASA EPSCoR project achieved its stated goals and, in countless ways, contributed to the economic and research infrastructure development of the State of Louisiana. Last, but not least, thanks are due to the dedicated project management staff in the NASA EPSCoR office - - the Program Manager, Office Assistant, Web Master and Student Worker.

FINAL PROJECT REPORT

"Louisiana NASA EPSCoR Project"

This is the final report for the Louisiana NASA EPSCoR Project (1994-2001), a federal-state partnership between NASA and the Louisiana Board of Regents. The NASA EPSCoR project in Louisiana was awarded in 1994 under NASA Cooperative Agreement NCCW-0059. The original award was for \$500K per year for three years (1 June 94 to 31 May 97), for which Board of Regents (BOR) matching funds of \$500K per year were granted to meet the required 1:1 match for this program. After two years the project was transitioned to GSFC which involved closing the original Cooperative Agreement (CA) and re-opening the project with a new CA (NCC5-167) under which the remainder of the project was conducted. The NASA EPSCoR RFP stipulated a total program of five years, with an evaluation in year three to qualify for the final two years. Louisiana was successful in this review. Upon reaching the five year maturity of the award, NASA elected to offer two continuation years. Louisiana was again successful in applying for these continuations. The total funding for the project reached \$3.3M in NASA funds with \$2.75M in BOR matching funds, supplemented by over \$2M in institutional contributions.

I. PROJECT OVERVIEW

The Louisiana NASA EPSCoR Program utilized a mentoring approach, combined with the research cluster model, to build Aerospace related R & D capability in the state. Three research clusters were established under the aegis of the Louisiana Board of Regents for Higher Education, the contracting institution, to focus on particular areas of relevance to NASA which hold high potential for the enhancement of scientific research, higher education and the development of the state's capabilities in:

- Space Science - - "The Louisiana Balloon-Borne Experiment Cluster" (Balloon Cluster)
- Aerospace Technology - - "Spray Combustor Performance Improvements through Forcing" (Propulsion Cluster)
- Earth Science - - "Carbon Cycling and Hydrology in a Shallow Coastal Estuary" (Global Change Cluster).

Together, these clusters involved researchers at 10 institutions, including three HBCU's and two regional universities. The overall objective was to develop the research potential at the smaller schools through direct involvement with, and mentoring by, the established researchers at the larger schools, and to involve students (undergraduate as well as graduate) directly in the research on each campus. The potential for technology transfer played an integral part in the project.

Overall, this Louisiana NASA EPSCoR Project has involved over 27 faculty members, ranging from new assistant professors to established researchers, plus seven postdoctoral researchers. Additionally, over 40 graduate students and close to 100 undergraduate students were directly involved in the research. The Minority Summer Research Experience (MSRE) provided minority Educators with summer research experiences by working directly with the clusters. The benefits of these activities are already large, and long-lasting, and may well lead to greater involvement for Louisiana researchers in Aerospace science and technology.

The Louisiana NASA EPSCoR Program scientific and technical management team is lead by the state Project Director, John P. Wefel, Department of Physics and Astronomy, Louisiana State University, Baton Rouge. Other management team members include Program Manager Karen Johnson, assistant Amy Eads, and web masters Doug Granger and Robby Perkins (student worker). Further, Roy Keller of the Louisiana Business and Technology Center, provided coordination and advice concerning technology transfer issues.

Louisiana is a poor state dependent mainly upon agriculture and the energy industry. Louisiana's future is tied to economic development, particularly to diversification into high-tech (non-polluting) industries. The key to this is developing a base of technically-trained personnel, and Louisiana's universities are poised to provide the R & D and educational leadership necessary for broadening the economic base. Thus, Louisiana's long-range objective is to increase the R & D capabilities and the technical skills of its students and researchers, and this is the overall theme that was addressed by the NASA EPSCoR project.

II. PROJECT ACCOMPLISHMENTS

Significant progress was achieved early in the NASA EPSCoR project. In addition to data acquisition and modeling activities and papers/publications, there were other outcomes. In the true EPSCoR spirit of research capability building, Balloon Cluster Co-PI at LaTech, Dr. Kathleen Johnston, enthusiastically reported that as a direct result of her work on NASA EPSCoR, her department (which had been in danger of dissolution) gained significant administration support, student enrollment increased, and new faculty were added!

A. Research Cluster Accomplishments

This project provided Research Capability Enhancement and Research Infrastructure Development in Aerospace fields for the State of Louisiana. The NASA EPSCoR program built upon and complemented the work of the Louisiana Space Grant organization and extended the development of scientific and engineering expertise through building Research Clusters. Such clusters provided a research focus and a nexus for human resource development.

1. Global Change Cluster

Introduction: This multi-institution project, entitled "Carbon Cycling and Hydrology in a Shallow Coastal Estuary," combined researchers from five institutions and a variety of disciplines to tackle one of the fundamental problems in Earth System Science (and an issue of

intense interest and great relevance for the Louisiana Gulf Coast region) - - the movement and fate of Carbon in the coastal estuarine system. This coordinated investigation of the Land/Sea Interface in Barataria Bay in the Louisiana coastal wetlands combined Physical, Biological, Hydrological and Botanical work with Remote Sensing (RS) using both existing and newly developed technologies, and data from both aircraft and space-borne sensors. The goal was to obtain a set of measurements (both aerial and ground truth) to derive a physical model of the site, its inter-relationships and its temporal changes. This project continues to develop the state's capabilities to carry out complex, integrated (interdisciplinary) studies, making Louisiana researchers more competitive for further work, possibly at other locations worldwide, as part of the international Global Change initiative.

The project was organized around task areas (Physical processes, Biogeochemistry, Soils, etc.) rather than institutions or departments, and involved new technology through Active Electromagnetic-Induction Sensing and aircraft overflights. The cluster combined researchers at Dillard (HBCU) with instrumentation expertise at UNO, with coastal processes work at LSU, with soils expertise at the LSU Agricultural Center, with the in situ sampling and analysis capabilities of LUMCON (Louisiana Universities Marine Consortium), and involved direct collaboration with researchers at NASA Stennis Space Center. The project continues to develop new remote sensing techniques which may have commercial potential.

Discussion: In shallow, fine-grained coastal environments, water-column/seabed interactions are intensified through physical and chemical processes such as deposition, resuspension, adsorption/desorption, and precipitation. These processes make coastal margins important in understanding the chemical evolution of our oceans, as well as the input history and fate of many toxic metals and organic compounds in our marine environment. Therefore, the transport of sediment and particulate organic carbon on seasonal and decadal time scales was investigated by utilizing the radioisotopes ^7Be , ^{210}Pb and ^{137}Cs . In addition, seasonal resuspension of estuarine bottom sediments were investigated through the modeling of wind induced waves and remote sensing techniques. The specific objectives of this work were as follows:

1. Quantify sediment deposition (monthly) and burial (decadal) at discrete subaqueous sites (ranging from fresh to salt water) within the basin;
2. Quantify organic carbon deposition and burial in subaqueous sediments within the basin;
3. Differentiate seasonal organic carbon sources (allochthonous vs. autochthonous) to subaqueous sediments within the basin;
4. Quantify the frequency and duration of sediment resuspension for select water bodies within the basin.

We achieved success in all four objectives.

Short-term sediment and organic carbon deposition: During an initial 12 month reconnaissance period cores were collected throughout the aquatic environments of Barataria Basin and analyzed for Be-7 to determine the best sites to represent open water and marsh-proximate environments. A complete record of monthly deposition rates was created at two primary sites: Little Lake North and Live Oak Bay. Organic carbon contents of the monthly

cores samples were also determined. Together with the bulk sediment deposition rates, these measurements permitted a calculation of the monthly organic carbon deposition at the two primary sites. The average annual rate of organic carbon deposition (determined from monthly rates) ranged from 100 to 1000 g C m⁻² yr⁻¹.

Decadal burial of bulk sediments and organic carbon: In addition to the primary sites for the deposition study, cores were collected from 12 other sites for Pb-210 determinations. These measurements permitted the calculation of sedimentation rates over the past 100 years. The long-term sedimentation was low (range: 0.1 to 0.3 cm yr⁻¹) compared to the monthly deposition rates and the average annual sedimentation rates derived from Be-7 measurements. POC burial rates (averaged over decadal time scales) from cores collected throughout the basin, range from 8 to 37 g C m⁻² yr⁻¹. Long term sedimentation rates were only 3-10% of the short term deposition rates. Organic carbon burial rates were only 2-7% of the average annual organic carbon deposition rates determined during the study.

Sediment and organic carbon resuspension and redistribution: Physical processes (e.g. vertical mixing and sediment resuspension) influence sediment and organic carbon mass flux and dispersal. Storms have previously been recognized as important forcing mechanisms for sediment transport in shallow, micro-tidal coastal environments, such as the Barataria Basin where wind induced waves can be the dominant physical forcing mechanism. The seasonal characteristics of material transport were examined using an empirical model of sediment resuspension as a function of wind direction, wind speed, fetch over water and water depth. The model was verified using satellite remotely sensed radiance information (i.e. visible and near-IR channels) from the AVHRR instrument. Results of the model indicated that during the winter and spring, conditions necessary for resuspension were exceeded over 50% of the time. The net wind forcing was to the south resulting in a net down-basin transport of sediments and organic carbon. These redistributions probably resulted in a gradual export of materials down-basin but still does not explain the 10-fold difference in deposition and burial rates.

Results from the short-term deposition rates and the long-term burial rates, in conjunction with the transport model suggest that low frequency (high energy) events that occur on time scales of 5-10 years are responsible for the bulk of sediment and organic carbon transport out of Barataria Basin and into the coastal ocean. The most likely candidates are tropical storms and hurricanes which (on average) have impacted Barataria Basin every 6-8 years during the past century.

In the first phase of the study, the exchange of carbon, sediment and water between brackish marshes and a shallow fine-grained bay of the Barataria Bay estuary was examined in order to quantify the production, transport and storage of carbon in the Barataria Basin. Factors controlling these exchanges were identified and measured. Fluxes of suspended sediments through a tidal bayou connecting marshes and open waters were measured throughout the year and during a variety of weather events. Discharge of porewater from the marsh substrate to surrounding waters via subsurface flows and surficial drainage channels was measured. Results indicated that the bayou discharges sediment during typical summer conditions and imports sediment during the winter. Late summer storms, occurring during the period of highest water level, are the largest sedimentary events and result in large net imports of sediment. The bayou

marsh system is a net importer of sediments from the bay. Sediment flux is controlled by water level in relationship to marsh surface elevation, wind speed, direction and duration, tidal prism volume and seasonal factors such as invertebrate activity in the marsh. An extensive network of surficial channels or rivulets exists on the marsh surface, resulting in porewater discharge from parts of the marsh that are distant from the bayou. Porewater seepage into rivulets cannot account for the volume of discharge observed. Diffusion of porewater constituents into a thin surface layer of water, and flow of the layer toward the rivulet, is suggested as the primary route of constituent discharge.

In the second phase of work, the identity of sediment sources in the previously characterized system was examined using stable isotope techniques. Bay and bayou sediments, suspended sediments and marsh soils were characterized for $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and $\delta^{34}\text{S}$ using natural abundance mass spectroscopy. The use of these three isotopes in tandem has been used successfully in previous studies to establish the flow of organic matter in estuarine food webs. The technique relies on differences in $\delta^{13}\text{C}$ between upland C-3 plants and C-4 plants such as *Spartina* as well as phytoplankton. The $\delta^{15}\text{N}$ ratio is higher in phytoplankton than terrestrial vegetation. $\delta^{34}\text{S}$ provides an additional tool since the source of inorganic sulfur in algae, *Spartina*, and upland plants are different. The methods were applied to sediments of the bayou and Bay over a year and a half sampling period. Bottom sediments in both the bayou and Bay were strongly associated with stable isotope signatures of C-4 plants such as *Spartina* and *Juncus* and not upland or more freshwater marsh species. In general, seasonal differences could be explained by sediment movement patterns observed during Phase 1 of the study. There was little or no evidence of organic matter of upland sources observed at this location in the Barataria Basin. This suggests that existing marsh stands and the associated biomass are the significant sources of carbon flow in the system. The study confirms the utility of the multiple isotope technique in tracking the sources of sediment. Coupled with remote sensing, the combined technique could provide a powerful tool for tracking sediment flow in coastal estuarine systems.

We studied the fate of Carbon and sediments within the Barataria Bay Basin, Louisiana and the water composition to assess seawater influence within the marsh. Ion exchange resin strips were used to study the effect of salinity and chloride (Cl) on sulfate (SO_4) reduction and their potential for water and soil analysis. Chloride dominated the water system and the Cl/SO_4 ratio can be used to assess the seawater influence. Resin extractable sulfur (S) predicted non-pyritic S fraction for the marsh soils. High salinity reduced the affinity of target ions onto the resin. Limited affinity of SO_4 to resin indicates SO_4 accumulation within the root zone, which promotes sulfate reduction and pyrite formation.

Landscape position and salinity effects pyrite accumulation and the spatial variability of soil characteristics within a saline and a brackish marsh. Salinity, pyrite, and non-pyritic iron (Fe) and S varied between streamside and inland. Depressions in mineral layer, accretion variations and associated hydrology caused the field-scale variability. When the inland site is landlocked, salinity and pyrite content within the surface horizon varied. Non-pyritic S, pH, and pyrite profiles were different in different marsh types. Mineralogical evidence also found for the presence of pyrite framboids. These soils should be reclassified to indicate accumulations of reduced sulfur.

Thickness of subsurface horizons was highly spatially variable. Variation in "depth to mineral layer" (DML) can be due to the presence of depressions in the mineral layer surface. Typic Medisaprists occurred mostly toward inland areas and away from waterways at the saline marsh. The DML was shallower for the degrading marsh within the saline marsh type. Typic Medisaprists within the brackish marsh had thick organic layers due to presence of thick subhorizons. Spatial variability is evident for pH and "organic/mineral ratio" (OMR) within organic subhorizons. The OMR data varied widely for the brackish marsh compared to saline marsh. Organic soil characteristics vary spatially due to variations in associated processes, therefore, spatial variability should be considered for soil sampling schemes.

We tested an experimental remote sensing instrument, an Airborne Electromagnetic Induction Profiler (AEM), in a novel environmental application in the estuarine Barataria Bay. The multidisciplinary character of the group allowed the collection of a wider variety of forms of ground truth than is common with experimental remote sensing instruments and certainly with AEM deployments. Our goals included demonstration of AEM capabilities over water, demonstration of AEM capabilities over land, and development of data processing techniques.

The Gulf of Mexico just offshore from Barataria Bay stratifies during the early summer period when the AEM was flown. CTD measurement from a boat verified that this was indeed true at the time of the flight and provided precise data on depths, temperatures and conductivities. The AEM data clearly showed the two layers in the water and located the bottom as well. This stratification of the Gulf waters provides the environment that allows the development of the hypoxic bottom waters called "Dead Zones." Similar stratification is believed to occur in coastal waters near rivers and estuaries around the world and dead zones have been found in a few of these areas including the Chesapeake Bay and the Baltic Sea. Since water column stratification is invisible to the optical and radar sensors normally used in remote sensing, this work helps to establish the AEM as an important new modality for remote sensing.

The land in the lower Barataria basin has very complex subsurface structure. As mentioned above, the ground truth sampling of the marsh soils revealed highly variable horizons (or layering) and the AEM data over this area clearly reflect this complexity. Observations of interest included the frequent presence of subsurface layers that were more conductive than the surface layer over them. This is presumably associated with salinity variations caused by depositional history. In general we found that the conductivity layering on the land varied so rapidly that it could only be interpreted by using a detailed map or optical image of the area.

We advanced the level of data processing in several areas. The two layer MIM models were extended to three to five layer models. We also extended the two layer least squares models to multiple layers. These extensions were necessary to analyze the complex data over the marshes. We also compared the results from MIM and least squares and found that they substantially agreed. This is an important conclusion for both methods, since it clarifies the MIM response to noise and model misfit, and it shows that MIM approximations could be used as starting points for least squares refinement. As it was needed to process the data, we developed a method for determining sensor altitude from the data itself. Even when an independent measurement of altitude is available, this method will provide a valuable consistency check.

Finally, we also developed a preprocessing technique for leveling the data to a common altitude. This process improves the performance of all the types of analysis algorithms.

During this program, a number of graduate students participated in processing remote sensing data over the Barataria Bay region southwest of New Orleans using an unsupervised classification approach. This phase of the project was the mapping of vegetation over this area using satellite data. As part of the classification project, then, several students participated in field work visiting areas that were indicated to be of the same spectral class. The final product was a detailed vegetation map of this region, from which direct inferences of salinity regimes could be accurately determined. This final result was a very accurate vegetational/salinity map of this area. Also, we believe, that because of changing shoreline/land masses, maps generated from this program will be extremely useful in the future to determine future land losses resulting from catastrophic hurricanes or extremely strong winter storms.

In conjunction with this work, some of the vegetation sampling field work was also carried out by undergraduates from Dillard University, an HBCU with a good program in remote sensing and environmental studies. Over the years a number of students have participated in summer field work programs, written their results up as reports and papers, presented these results in various venues, and then gone on to graduate school. In addition, there have been several masters and Ph.D. theses to come out of the project.

2. Balloon Cluster

Introduction: This Astrophysics/Space Science project, entitled "Louisiana Balloon-Borne Experiment Cluster," coupled researchers at LSU as mentors for an emerging capability at Southern (SUBR), Louisiana Tech University (LaTech) and the University of New Orleans (UNO). Building upon existing grants at LSU, the EPSCoR funds were used to develop capabilities at the other schools. An HBCU, a female assistant professor and a large urban university were involved. The long-term goal was to enhance the infrastructure, and thus competitiveness, by establishing a balloon experiment capability and relevant expertise in Louisiana.

Balloon experiments offer university groups distinct advantages over spaceflight missions: less expense, faster, student involvement, and a technology "testbed." Ballooning has emerged as one of the most successful NASA endeavors. Building upon a state award of \$240K to LSU for the construction of a balloon gondola system, this Cluster enhanced capability at the three institutions which do not now receive significant NASA funding. The Balloon Cluster effort has concentrated on a number of separate scientific projects: MARGIE (Minute-of-Arc Resolution Gamma ray Imaging Experiment), a program to design a balloon-borne coded aperture experiment for gamma ray/hard x-ray astronomy (LSU, LaTech, UNO); JACEE (Japanese-American Collaborative Emulsion Experiment), a program of balloon flights to measure the composition and energy spectrum of ultra-high energy cosmic rays (LSU, UNO); ATIC (Advanced Thin Ionization Calorimeter), an electronic instrument to study the charge composition and energy spectrum of cosmic ray protons and helium from 10 GeV to 100 TeV (LSU, Southern); and AMS (Alpha Magnetic Spectrometer), a project to construct and fly a magnetic spectrometer as an attached payload on the International Space Station, intended to

conduct a sensitive search for cosmic antimatter (LSU, Southern). Over the course of the project, some efforts reached fruition (JACEE, AMS) and were replaced by new efforts in gamma-ray astrophysics e.g. COMPTEL (SUBR, LSU), a possible space station experiment, ACCESS (LSU), neutrino astronomy, ICE CUBE (SUBR), and super-high energy cosmic rays, "Auger" (LSU, SUBR). In addition, the cluster supported the education and outreach activities of the new Highland Road Park Observatory. The main intention of the Balloon Cluster program was to involve the Louisiana Tech, Southern and UNO faculty and students in the NASA related projects; by so doing, to enhance their research capabilities; and at the same time to bring new manpower to bear on the projects. The final results are significant new measurements, and a research team that is competitive for NASA balloon research projects.

Discussion: EPSCoR has been a tremendous help to our research effort and the state of Louisiana in providing needed research and student training funds. In the case of the Louisiana NASA EPSCoR Balloon Cluster program, EPSCoR funding was directly responsible for:

- new advances in detection techniques for very high energy particles, which led to the development of a new approach to transition radiation detectors for energetic cosmic rays, and led directly to major involvement in the ACCESS satellite experiment proposed to NASA's MDEX program;
- developments in high resolution x-ray and gamma ray spectroscopy which have potential applications in medical imaging and gamma ray astronomy;
- supporting the construction of part of a major new cosmic ray astronomy experiment, launched successfully on a high altitude balloon from the Antarctic in December 2000, which provided new results about the acceleration of high energy cosmic ray particles and provided hands-on laboratory training for over 50 students as part of the ATIC experiment team at LSU and Southern; and
- supporting the preparation of an NSF Science and Technology Center proposal involving LSU and Southern in high energy astrophysics which, although unsuccessful in this round at NSF, received some excellent reviews and will be the basis of a NASA University Research Center proposal from Southern in May 2002.

In addition to LSU (the lead institution) and Southern, the Balloon Cluster also involved Louisiana Tech and University of New Orleans. With all three partner schools (Southern, Tech, and UNO), the idea was largely to mentor faculty at the partner schools by involving them in ongoing research projects at LSU. This worked best when there was close and frequent communication. In other words, this worked much better and more effectively between LSU and Southern (located 15 minutes apart in Baton Rouge) than between LSU and either Tech (5 hours away in Ruston) or UNO (1 hour away in New Orleans). Even when there were very specific project assignments, there was a need for close and frequent contact and a real presence of the LSU faculty and research staff in the partner institution laboratories working directly with the partner school students. This worked well at Southern and not as well at Tech and UNO. At Southern, Prof. Fazely's group now has its own ATIC funding and is an independent and functioning member of the ATIC team; Prof. Fazely and his students and postdoc have

contributed to the experiment and the analysis, and have presented talks at national and international meetings. EPSCoR worked well there. At UNO and Tech, largely because of the distances involved, it was not possible to establish as close ties, or to set up continuing and independent NASA funding – although the groups at both Tech and UNO do have funding from other agencies.

3. Propulsion Cluster

Introduction: This effort, entitled "Spray Combustor Performance Improvements through Forcing," was directed to air- or oxygen-breathing propulsion systems for aeronautics/space applications through experimental and theoretical study of the fuel injection and mixing regimes in the engines. Such improvements can be utilized by many industries within Louisiana, as well as by the Aeronautics industry, and may be a catalyst for new industry in the state. The long-range goal was to develop new capabilities in the propulsion area, at several institutions, and thereby form a team that will be highly competitive in this important technical area.

The experimental program built upon facilities in place at LSU and upon modeling capabilities at Tulane and LSU. These were utilized and augmented by researchers at Xavier University (HBCU), McNeese State University (regional institution) and Southern University (HBCU). The project brought together three different academic departments at five different schools in a multidisciplinary attack on this fundamental problem. The established researchers worked closely with the younger faculty on both the experimental and computational aspects. New experimental facilities were constructed at McNeese to augment and complement the testbed at LSU; new computational resources were provided at Xavier and at Southern, as well as developing new visualizing capabilities for the data. The results were followed closely for technology transfer potential.

Discussion: The propulsion cluster of the NASA-EPSCoR effort was directed at bringing together five Louisiana schools (LSU, Tulane, McNeese, Xavier, and Southern), and developing a mutually complementary research program directed towards improving the performance of gas turbine spray combustors. The tasks were divided as follows:

LSU would take the lead, and establish a spray combustion laboratory for detailed diagnostics. LSU would explore active and passive control strategies for performance improvements and would extend its basic computational capability for spray combustion, while assisting the other schools involved in the computational effort (Tulane, Xavier, and Southern).

LSU has achieved all its primary goals. A state of the art laboratory (nearly 3000 sq ft) has been established. Several federal and state grants that leveraged the NASA EPSCoR support and the associated combustion laboratory have been obtained (ONR, AFOSR, BORSF, NSF, totaling nearly \$2 million). This is more than a 2:1 leverage of NASA-EPSCoR money at LSU. The establishment of the laboratory was also instrumental in the development of the Turbine Innovation and Energy Research (TIER) Center which is now approved by the state of Louisiana. The TIER Center is currently competing in the NASA-URETI Center competition, and is supporting two NSF-ERC center efforts currently under preparation. Several students

(7 M.S, 1 Ph.D, 1 Post-doc, and many UG students) , and a large number of refereed journal and conference papers, have resulted from this effort.

Tulane's role was to develop a computational capability for two-phase flows applicable to spray combustion, and collaborate with LSU and Xavier as part of this effort. Tulane has accomplished all its major goals, with the development of a coupled two-phase code (in collaboration with LSU), and the establishment of a collaborative program with Xavier.

McNeese State University's task was to develop an experimental facility to perform detailed cold flow measurements in support of the reacting flow measurements at LSU. This task was accomplished. Two M. S students, two conference papers, and one journal paper resulted from this collaborative effort.

Xavier University's primary role was to assist in specific computational sub tasks, and to provide the visualization capability for the entire group. Xavier accomplished this task by effectively collaborating with Tulane and LSU. Collaboration with Tulane has resulted in transfer of students from Xavier (UG) to Tulane (Graduate). This collaboration has continued beyond the EPSCoR effort.

Southern University's role was to assist in the computational effort, and to use a commercial CFD code to model the experiments at LSU. The Southern PI relocated to another school in the fifth year of the effort, and Southern's tasks were taken over by LSU. These tasks have been completed as detailed in the report. The student working at Southern eventually transferred to LSU.

Overall, major advances were made in both experiment and in computational prediction. The facilities developed continue to be used by a variety of allied projects. Moreover, the computational techniques developed can be applied to a wide variety of situations involving flows. Detailed technical results are contained in the bibliography for this cluster (see Section IV).

B. The NASA EPSCoR Minority Summer Research Experience Program

The LA NASA EPSCoR project addresses two of Louisiana's long-range objectives: to increase its academic research and development capabilities, and to improve the education of its students. Combining these subthemes resulted in the inclusion of a Minority Summer Research Experience Program which awarded summer research fellowships to minority educators from secondary schools or colleges/universities to join one of the clusters and work directly with the researchers. In order to increase minority participation in cluster activities, funds were allocated to support a summer fellowship program to sponsor, on a merit-reviewed basis, summer research fellowships within each of the three clusters.

Educators were exposed to the laboratory environment where they interfaced with senior researchers as members of a research team while receiving hands on training in aerospace related areas of science and engineering. By understanding the educational levels and skills required for participation in university-level research and development, the teacher is better prepared to

mentor secondary students who are interested in pursuing studies which will lead to a career in science, engineering, or mathematics. In this way, it was hoped that the cluster research could be further leveraged to provide an extra level of human resource development and promote educational excellence.

There were seven participants over the summers of 1996 and 1997. Appointment was full time at the host institution. A MSRE fellowship carried a stipend of \$5000.00. The length of the award was 8 weeks. Award funds were provided to the cluster PI host, and paid to the educator according to standard university policies and procedures. In addition to spending the 8-week summer on campus with the cluster mentor, educators were to submit a written report within the following academic year detailing how the summer experience was imported into the classroom and shared with other educators, schools, or the community. Finally, candid and confidential comments were solicited from the participants and faculty to evaluate the meaningfulness of the experience.

The list of teachers and companion cluster are given below. Also indicated are the teachers who fulfilled the final report obligation. A total of 7 teachers (with one repeat) participated in the program.

MSRE Participants - 1996

Teacher	EPSCoR Cluster	Submitted Final Report?
Rutherford McNair Glen Oaks High School 13517 Rampart Court Baton Rouge, LA 70810 Grade: 10	Global Change (LSU)	Yes
Joan Bennett Baton Rouge Magnet High 6250 D'Juanna Drive Baton Rouge, LA 70811 Grade: 9-12	Propulsion (LSU)	No
Michelle Bethea Ferriday Junior High School P.O. Box 306 Clayton, LA 71326 Grade: 8	Balloon-Borne (LaTech)	Yes

MSRE Participants - 1997

Teacher	EPSCoR Cluster	Submitted Final Report?
Michelle Bethea Ferriday Junior High School P.O. Box 306 Clayton, LA 71326 Grade: 8	Balloon-Borne (LaTech)	Yes

MSRE Participants 1997 continued

Robert Davis Pierre A. Capdau Junior High 3000 Cambridge LaPlace, LA 70068 Grade: 8-9	Propulsion (Xavier)	No
Betty Odom McKinley Middle Magnet 5925 San Juan Drive Baton Rouge, LA 70811-4128 Grade: 7-8	Global Change (LSU)	No
Erica Jones Sherwood Middle School 12115 Warfield Avenue Baton Rouge, LA 70815 Grade: 8	Global Change (LSU)	No
Donald Dunn Francis W. Gregory Junior High P.O. Box 346 St. Rose, LA 70087 Grade: 9	Global Change (UNO)	No

Participants in the program reported mixed reactions. Most of the teachers enjoyed the experience of working with a scientist and felt they learned a lot about a career in science and that they could relate this to their students. The faculty/mentors, although willing to volunteer to participate in such an experience, reported such limitations as tailoring meaningful work to the capabilities of the teacher, and, in a few cases, reported teacher absences. However, the faculty were mostly pleased with the opportunity.

A flaw in the program design was revealed when some of the teachers failed to fulfill their obligation to submit a final report, despite numerous request letters over several years. Without this feedback, it was impossible to evaluate the degree of encouragement of minority students to consider a career in science. The one shining counter-example was the report from Rutherford McNair, who took his students on field trips (to CAMD, for example) and conducted semester long water quality projects, in collaboration with his faculty mentor Larry Rouse.

C. Management, Technology Transfer and Business/Industry

Program Management: Management activities involved progress tracking, report preparation, review coordination, evaluation, public relations and project representation and promotion. These were quite successful including hosting NASA EPSCoR Project Director Julius Dasch and Liz Ward for a meeting in New Orleans and Julius Dasch at the statewide EPSCoR conference. We also developed a web page (<http://phacts.phys.lsu.edu/EPSCoR>) and maintained a NASA EPSCoR list serv. There were various Presentations and Posters, including:

- National Space Grant - EPSCoR Joint Conference, Williamsburg, VA 1996
- NSF EPSCoR National Conference, Washington, DC
- Baton Rouge Earth Day, 1996
- Louisiana Stimulus for Excellence in Research (LaSER) Conference, Baton Rouge, LA
- National EPSCoR Retreat, Wintergreen Resort, VA, January, 1998
- "LA Aerospace Forum Proceedings," 1995 (LaSPACE)
- Contributions to BOR publications, e.g. Research Dividends, vol. 2, No. 1 (1999).

• **Coordination:** One development was the formation of the Louisiana EPSCoR Project Directors Subcommittee under the direction of the then NSF project director, J. P. Draayer. This subcommittee met at Tulane with the representatives of Louisiana's NSF, DOE, NIH and NASA projects in attendance. Issues addressed included roles and missions, evaluation and "graduation" from EPSCoR status, new statewide initiatives which may interact with the various projects, a statewide researcher database, indirect cost rates for systemic projects, and the statewide conference. The discussion revealed that all of the EPSCoR efforts, while different, do have many common concerns that can be addressed at the statewide level.

An other major event was the statewide conference, sponsored by the state EPSCoR committee. In addition to valuable plenary sessions, there was a specific NASA/DOD session, plus a poster session at which the NASA EPSCoR project is displayed. These stimulated much discussion. Further, the EPSCoR technical monitor from NASA Headquarters, Dr. E. Julius Dasch, was an invited participant, and obtained an overall "Louisiana" perspective as well as coordinating with the local NASA project and other statewide efforts.

• **Evaluation:** There were two levels of Evaluation involved in this project, local and out-of-state. Locally, we established regular Cluster Investigator Team (CIT) meetings. The CIT involved the leader of each of the research clusters, the statewide PI, and the program management personnel, augmented by other individuals as needed. The purpose of the CIT was to discuss common problems or occurrences and to focus on the overall statewide goals of the project.

Out-of-state evaluation involved a "visiting committee" composed of 'experts' in the different cluster R & D areas as well as more general researchers involved with the EPSCoR focus of the project. This team had a full review of the project in late spring 1996. The team (James Hubbard, Jr., Boston U.; David Bartlett, U. of NH; John Daily, U. of CO; John Connolly, U. of KY; George Nakano, Lockheed-Martin) pointed out that the triad of identifiable elements for the success of an EPSCoR program were (1) Relevant Technology, (2) Diversified Intellectual Resources and (3) Strong University Commitments. Measured against these elements and against Louisiana's proposed program goals, the team concluded that "Overall, the Louisiana NASA EPSCoR is doing a good job encouraging junior investigators and threshold

scientists to bring their research to the nationally competitive level. . . . the mentoring strategy is working well.” The team also pointed out a number of specific areas for strengthening, and these suggestions were acted upon by the clusters.

Technology Transfer and Business/Industry: The Clusters’ research did not reach a level where there were specific products or licensing agreements, but, in anticipation, the project involved Roy Keller, the director of the Louisiana Department of Economic Development’s Technology Transfer Office, operated by the Business and Technology Center at LSU in collaboration with the Stennis Space Center. His objective was to educate the researchers about the availability and methodology of technology transfer and to be aware of developments in the research. He was also the Louisiana representative to the Southern Technology Applications Center (STAC), and the Louisiana ‘Global Change’ Cluster was cited in a STAC publication (“Success Stories in Technology,” 2/96, p. A-9).

In addition, relations with industry developed. The ‘Propulsion’ Cluster collaborated with Allison Engine Co. (who donated a commercial spray nozzle), Pratt & Whitney, TRW, and Parker-Hannefin Co. (who built a research simplex atomizing nozzle). Fluent Inc. provided a complementary copy of the license for their CFD software and was an active consultant. Meanwhile, CIC, Inc. and BASF, Inc. provided the industrial linkage for a joint LSU-Industry project in fire suppression, and CIC, Inc. also provided consultation on electrostatic fuel injection. The ‘Balloon’ Cluster’s MARGIE program, developing new high resolution detectors, has worked with industry on two projects: 1) Radiation Monitoring Devices, Inc. (Watertown, MA) has produced (working under subcontract) samples of fine-grained Cesium Iodide microfiber arrays with applications for cancer therapy and medical imaging; and 2) Suni Imaging Microsystems, Inc. (Mountain View, CA) has fabricated initial prototypes of a fast timing charge coupled device which may be useful for medical imaging, military reconnaissance, and industrial imaging, when both spectral and time resolution is required. A patent was granted to Balloon Cluster participants for part of these developments.

Federal Laboratories and Agencies: In addition to Business and Industry, significant ties were formed with federal (and state) agencies. The Global Change Cluster collaborated directly with NASA SSC while the Balloon Cluster collaborated with NASA MSFC, GSFC and JSC. The Propulsion Cluster coordinated with NASA GRC and SSC as well as with AFOSR Wright Labs in Dayton, OH. Both Balloon and Global Change worked with the Naval Research Laboratory, and Propulsion and Balloon Cluster researchers received support from the Department of Energy and National Science Foundation. ONR provided support for Propulsion Cluster spinoff projects, and NASA support was generated for many of the Balloon Cluster's projects.

While focusing here on federal agencies, we must point out that the successful outcomes would not have been possible without the help of many other state and federal agencies, among them the Board of Regents Support Fund, the US and LA Geological Survey, the Army Corps of Engineers, the US Biological Survey and a variety of state agencies.

III. OVERALL PROGRAM ASSESSMENT

The NASA EPSCoR Program in Louisiana was a tremendous success! Two of the clusters progressed to the level of submitting Center proposals to the NSF Science and Technology Centers and NSF Engineering Research Centers competitions and to the NASA URETI competition. Although neither has been successful, so far, this is a remarkable indicator of development. Moreover, such proposals require collaborations with researchers outside the state, and these LA NASA EPSCoR researchers have "made-a-name" for themselves in the national and international community.

The project outcomes, provided in detail in the next section, tell a similar story. Overall, there have been 75 publications in referred journals and several more are in preparation based upon continuing work in these research areas. There were 130 other publications, mainly in conference proceedings, and over 100 presentations (invited and contributed) made about the projects. This represents a very wide dissemination of the research results.

The groups also worked hard to attract additional support for both the core research areas and allied, spinoff projects. In total \$18 Million in external support was generated. Of this \$2.8 Million came from a private company/foundation, but the remainder was generated from federal and state sources. This is a return on investment of over 2 to 1, an achievement of which the clusters are justifiably proud.

While only one patent was granted during this project, which has not led, yet, to any commercialization, numerous contacts were developed with state and federal agencies and with private industry and non-profit groups. Such contacts both benefited the overall program and remain important for future endeavors.

Perhaps the greatest success story is the students. Over 150 students were involved in the research with 60-70% of them undergraduates. As a result of the project, 42 advanced degrees have been awarded to date, six Ph.D. degrees and 36 master's degrees. Several additional are in the pipeline. The involvement of the undergraduate students in main-stream research may be the most long-lasting of the outcomes. This is particularly important for the smaller schools for which this EPSCoR project represented a major opportunity. We had students participating in all phases from field work, to building experimental hardware, to analyzing data. Not all stayed with the project for extended periods, but many did, working on the research for 2-3 years before graduating. Many went on to graduate school at good universities while others have taken jobs with business/industry.

In the area of building capability at the smaller schools, the success was not overwhelming. In all cases, the researchers at these schools remained involved (gaining experience) and involved students in the project. This also generated interest on the campus. In the infrastructure area, many of the smaller schools realized that they did not have the staff to support grants and contracts, and, if they were going to participate, would have to develop these administrative areas. That has led to, in one case, the creation of an Office of Research, where none existed previously, and in several cases to hiring a grants and contracts administrator. In

addition, faculty release time was provided, and documented, space was made available for the project and, in a few cases, needed equipment was provided.

Some of the faculty developed good working relationships with faculty at other cluster campuses and discovered an overlap of interests. Several formed collaborations and received support for projects that were spun-off from the cluster research efforts. While some faculty have initiated follow-on efforts, others have not. Perhaps it is still too early to judge the degree to which capability, interest and infrastructure were developed in all cases. However, the follow-on efforts that have been initiated attest to the overall success of the mentoring model.

IV. PROJECT DOCUMENTATION

Below we present the final project documentation for the three research clusters divided as follows:

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Section I: Refereed Publications

*Students

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C. J. Bergeron, N. Yi, J. W. Ioup and G. E. Ioup, "Low Pass Filtering of AEM Field by MIM Impulse Function", *MTS Journal*, **30**, No. 4, (1996).

Section I: Grants and Financial Awards

Topic: Louisiana Balloon-Borne Experiment Cluster

NASA, "Astronomy Education/Outreach for K-12 and Under-Represented Students and Teachers", Three years, \$40,000, 3/1/98 - 3/31/01 (LSU), **Implementation Date 3/1/98.**

Louisiana Board of Regents, "Enhancement of Undergraduate Education in Astronomy at SUBR: From the Classroom to the Universe", Three years, \$106,785, 7/1/99-6/30/02 (Southern), **Implementation Date 7/1/99.**

Louisiana Systemic Initiatives Program, "Physics Learning and Astronomy Training Outreach (PLATO)", Two years, \$297,000, 6/1/99 - 5/31/01 (LSU), **Implementation Date 6/1/99.**

NASA, **"MARGIE Education/Public Outreach"**, \$7500, Two years, 12/1/98 – 11/30/01, (LSU), **Implementation Date 12/1/98.**

NASA, **"SIFTER Education/Public Outreach"**, \$10,000, 7/1/00 – 6/30/01, (LSU), **Implementation Date 7/1/00.**

Louisiana Technology Innovation Funds, **"Training Today's Students for Tomorrow's Internet Work Environment"**, Two years, \$275,000, 4/1/00 - 3/31/02 (LSU), **Implementation Date 4/1/00.**

NASA, **"X-Ray and Gamma Ray Astrophysics Education/Public Outreach"**, Three years, \$30,000, 4/1/01 – 3/31/04 (Southern), **Implementation Date 4/1/01.**

DOE, **"Auger Project Operations"**, One year, \$120,000, FY 2001 (LSU), **Implementation Date 4/1/01.**

NASA, **"MARGIE – Minute of Arc Resolution Hard X-Ray/Gamma Ray Imaging Telescope for an Ultra Long Duration Balloon Mission"**, Two years eight months, \$550,000, 3/19/01 – 11/30/03 (LSU), **Implementation Date 3/19/01.**

NASA, **"Partnerships in Astronomy and Astrophysics Education and Research at Southern University"**, Three years, \$580,000, 1/15/01 – 1/14/04 (Southern), **Implementation Date 1/15/01.**

DOE, **"Auger Project Operations"**, One year, \$114,000, FY 2000 (LSU), **Implementation Date 4/1/00.**

DOE/NSF, **"Auger Project Construction"**, One year, \$85,000, FY 2000 (LSU/Southern), **Implementation Date 1/1/00.**

NASA, **"A Survey of Active Galaxies and High Latitude Gamma Ray Sources Using All Sky Maximum Likelihood Maps"**, Two years, \$7500, 2/1/99-1/31/01 (LSU), **Implementation Date 2/1/99.**

NASA, **"SIFTER: Scintillating Fiber Telescopes for Energetic Radiation, Gamma Ray Applications"**, One year, \$41,500, 4/1/00-3/31/01 (LSU), **Implementation Date 4/1/00.**

Univ. of Alabama (Huntsville), **"LSU Electronics Design for FiberGLAST ATD Program,"** One year, \$120,000, 3/1/99 - 1/31/2000 (LSU), **Implementation Date 3/1/99.**

DOE, **"Auger Project Operations"**, One year, \$108,000, FY 1999 (LSU), **Implementation Date 4/1/99.**

DOE/NSF, **"Auger Project Construction"**, One year, \$102,000, FY 1999 (LSU/Southern), **Implementation Date 1/1/99.**

NASA, "Simulation and Testing of Event Trigger Designs in Support of FiberGLAST Instrument Development", Two years, \$199,020, 9/1/99-8/31/01 (Southern), **Award date** , **Implementation Date 9/1/99.**

NASA, "PKS 0208-512 and GRO J0516-609 as MeV Blazars: A Reevaluation", Two years, \$6000, 12/1/99-5/1/01 (LSU), **Implementation Date 12/1/99.**

NASA, "An Alternative Method for Analyzing Diffuse Emission Using COMPTEL", One year six months, \$8000, 12/1/99-5/1/01 (LSU), **Implementation Date 12/1/99.**

NASA, "Development of a Balloon-Borne X-Ray/Gamma Ray Detector for Studies of High Energy Astrophysical Sources and Related Space- and Ground-Based Multiwavelength Observations", Three years, \$297,000, 3/1/98-2/28/01 (Southern), **Implementation Date 3/1/98.**

LEQSF Research Competitiveness, "Bi-Directional Charge Coupled Devices for Fast Timing Readout Applications," \$122,500, Two years, Southern/LSU, **Award date 5/1/98, Implementation Date 7/1/98.**

NASA, "Development of a Balloon-Borne X-ray/Gamma-ray Detector for Studies of High-energy Astrophysical Sources and Related Space- and Ground-Based Multiwavelength Observations," \$297,660, Three years, Southern, **Award date 1/98, Implementation Date 4/1/98.**

NASA, "Transition Radiation Detectors for High Energy Measurements on ACCESS," , \$280,000, Three years, LSU, **Award date 12/19/97, Implementation date 4/1/98.**

NASA, "Astronomy Education/Outreach for K-12 and Under-Represented Students and Teachers," \$10,000., two years, LSU, **Implementation Date 1/1/98.**

DoD (ONR) EPSCoR, "Synthetic Environment Reconstruction for Military Training and Mission Planning and Rehearsal," , \$235,950, Three years, UNO, **Award date 10/97, Implementation date 12/97.**

NSF, "Antarctic Long Duration Balloon Flights for the JACEE Collaboration," Data analysis and continued long duration Antarctic flights for the JACEE balloon program, \$20,000, One year, LSU, **Award date 05/97, Implementation date 6/1/97.**

LEQSF, "A High-Performance Computing Environment for Concurrency Research and Development in the Computer Science Department," , \$92,000, One year, UNO, **Award date 04/97, Implementation date 6/1/97.**

NIJ (National Institute of Justice), "Affordable Crime Mapping and Information Sharing Technology for Community Police Officers," , \$203,000, One year, UNO and NOPD, **Award date 03/97, Implementation date 06/97.**

NASA, **"Minute of Arc Resolution Gamma ray Imaging Experiment (MARGIE),"** Development of MARGIE balloon flight experiment, \$150,000, Three years, LSU, **Award date 10/01/96, Implementation date 05/01/97.**

NASA, **"Advanced Cosmic Ray Composition Experiment for the Space Station,"** Concept study for new instrument to be flown ~2005 on the Space Station, \$66,000., Two years, LSU, **Award date 08/19/96, Implementation date 02/01/97.**

FM (Freeport-McMoran), **"The Pontchartrain Lake Unified Management Consortium,"** \$2,800,000, Four years, UNO, **Award date 06/96, Implementation date 09/96.**

NSF/Louisiana Board of Regents, **"Joint Faculty Positions in Astrophysics,"** Joint Southern-LSU faculty appointments in high energy astrophysics, \$410,000, Two years, LSU and Southern, **Award date 5/23/96, Implementation date 7/1/96.**

NASA, **"Design and Development for a Minute of Arc Resolution Gamma Ray Imaging Experiment,"** Continued design and development of high resolution CsI, CCD, and CdZnTe gamma ray detectors for x-ray and gamma ray astronomy, \$50,000, Six months, LSU, **Award date 5/20/96, Implementation date 7/1/96.**

NSF, **"High Energy Interactions and Energy Spectra of Cosmic Rays,"** Study of high energy cosmic ray composition and nuclear interactions using balloon-borne emulsion chambers, \$375,111, Three years, LSU, **Award date 5/15/96, Implementation date 4/1/96.**

Louisiana/LEQSF (State), **"A Pointing System for MARGIE, a Minute of Arc Gamma Ray Imaging Experiment,"** Software design and implementation of NTASS for aspect determination system for pointing vector identification, \$67,236, Two years, Louisiana Tech, **Award date 5/6/96, Implementation date 6/1/96.**

NASA/LaSPACE, **"A Pointing System for MARGIE, a Minute of Arc Gamma Ray Imaging Experiment,"** Hardware design/development for MARGIE aspect determination system, \$16,340, One year, Louisiana Tech, **Award date 1/27/96, Implementation date 3/1/96.**

NRL, **"Development of a Digital Mapping Database with Modelling and Simulation Extensions to be Compared to an Extended VPF Database,"** \$69,213, One year and four months, M. Abdelguerfi, UNO, **Award date 06/95, Implementation date 07/95.**

NASA, **"The Advanced Thin Ionization Calorimeter (ATIC) Balloon Experiment",** \$3,154,267, Six years, 3/1/95-5/6/01, LSU, **Implemation Date 3/1/95.**

NASA, **"A Calorimeter Prototype for the Study of 10 GeV/nucleon to 100 TeV/nucleon Cosmic Rays,"** BGO calorimeter prototype studies for the ATIC balloon-borne cosmic ray composition experiment, \$747,467, Three years, LSU, **Award date 1/18/95, Implementation date 4/1/95.**

Topic: Spray Combustor Performance Improvements through Forcing

AFOSR, "A 3D-PIV for Gas Turbine Engine Applications," \$200,425, One year, 7/00 - 6/01, S. Acharya, and D. Nikitopoulos, LSU, **Implementation Date 7/00.**

LEQSF and NSF-EPSCoR, "Planning Grant for Center for Advanced Gas Turbine Technology," \$58,516., One year, 3/00-2/01, S. Acharya, D. Nikitopoulos, S. Ekkad, K. Kelly, and W. Meng, LSU, **Implementation Date 3/00.**

DOD-ONR "A five-year B.S./M.S. program between Xavier and Tulane Universities of Louisiana," \$124,000, Three years, 7/99 - 8/02, Dr. Eschenazi (co-pi), LSU, **Implementation Date 7/99.**

DOD-ONR "Sedimentation and Resuspension Studies for the Mississippi River and the Louisiana Environment," \$399, 000., Three years, 7/99 - 11/02, Drs. Eschenazi and Steinberg (co-pis), LSU, **Implementation Date 7/99.**

NSF - National Computational Science Alliance, "Large Eddy and Direct Numerical Simulations of Forced Flow in Combustor Geometries," \$600,000., One year, 1/1/99-12/31/99, D. E. Nikitopoulos, LSU, **Implementation Date 1/1/99.**

LEQSF, "State-of-the-Art Digital Visualization Equipment for Multi-Phase Research," \$182,178., One year, 6/1/98-5/31/99, D. E. Nikitopoulos, et al., LSU, **Implementation Date, 6/1/98.**

AFOSR, "Mixing and Combustion in Vortex Dominated Combustors with Distributed Air and Fuel Injection," \$820,000, Three years, S. Acharya, E. Gutmark, M. Murphy, **Award Date 3/98, Implementation Date, 8/98.**

NCSA (National Computational Science Alliance), "Large Eddy and Direct Numerical Simulations of Forced Flow in Combustor Geometries," 4,000 Service Units on the MHPCC IBM-SP, One year, D. E. Nikitopoulos, LSU, **Award date 12/18/97, Implementation date 1/1/98.**

NASA/LaSPACE, "Mist Generation for Fire Suppression Applications," \$15,000, One year, D. E. Nikitopoulos, E. J. Gutmark, and S. Acharya, LSU, **Award date 09/15/97, Implementation date 10/01/97.**

NSF, "Mechatronics Experiments in Mechanical Engineering Laboratories," \$57,815, Two years, A. Jana, G. Joshi, M. Sozen, P. Mensah, S. Ibekwe, M. Dunn and S. Chehl, Southern University, **Award date 06/97, Implementation date 08/97.**

ONR, "Swirl-Stabilized Spray Combustion Control," \$346,970, Three years, S. Acharya and E. Gutmark, LSU, **Award date 05/97, Implementation date 07/97.**

Louisiana/LEQSF (State), **“Development and Testing of Improved Systems for Fire Suppression,”** \$210,000, Three years, D. E. Nikitopoulos, E. J. Gutmark, S. Acharya, M. Van Gundy and A. Walker, LSU, **Award date 05/97, Implementation date 06/97.**

ONR, **“A Phase Doppler/Rainbow Refractometer System for Actively Forced Spray Combustor,”** \$240,000, One year, S. Acharya, E. Gutmark, and D. Nikitopoulos, LSU, **Award date 03/97, Implementation date 6/97.**

Louisiana/LEQSF (State), **“A Three-Component Phase Doppler System for Measurements in Single-Phase/Multi-Phase, Reacting/Nonreacting Flows,”** \$294,046, One year, S. Acharya, E. Gutmark, D. Nikitopoulos, T. Garrison, and K. Kelly, LSU, **Award date 04/97, Implementation date 06/97.**

DOE, **“Fate and Transport Modeling of radionuclides and contaminants in surface aquatic environments-Swamps, Bayous and Rivers, in Louisiana and Belarus,”** \$189,500, One year, E. E. Michaelides, L. Steinbert and S. J. Ramer, E. Eschenazi, Tulane and Xavier, **Award date 1/6/97, Implementation date 2/1/97.**

NASA/LaSPACE, **“Mist Generation for Fire Suppression Applications,”** \$15,000, One year, D. E. Nikitopoulos, E. J. Gutmark, and S. Acharya, LSU, **Award date 09/15/97, Implementation date 10/01/96.**

ONR, **“An Integrated Two-Component Phase-Doppler/Rainbow Refractometer System for an Actively Forced Spray Combustor,”** \$239,538., One year, S. Acharya, E. Gutmark and D. E. Nikitopoulos, LSU, **Implementation date 06/97.**

DoE, **“Collaborative Research with IREP and CREM of Belarus to Determine the Fate and Transport of Radionuclides following the Chernobyl Accident,”** \$177,000, One year, E. E. Michaelides, L. Steinbert and D. J. Sailor, E. Eschenazi, Tulane and Xavier, **Award date 1/15/96, Implementation date 02/01/96.**

EPA, **“Laser Diagnostics of the Combustion Process within a Rotary Kiln Incinerator,”** \$75,233., Three years, D. E. Nikitopoulos and E. J. Gutmark, LSU, **Implementation date 09/01/96.**

NASA/Ames Research Center (Computational Aero Sciences), **“Large Eddy Simulations of a Forced, Coaxial Spray Combustor,”** (1450 hours of CPU time on a SP-2), Two year, D. E. Nikitopoulos and S. Acharya, LSU, **Award date 9/95, Implementation date 10/2/95.**

Louisiana/LEQSF (State), **“Combustion Equipment Enhancement,”** \$132,250, Two years, F. C. Knopf, K. M. Dooley, M. A. Henson, D. Nikitopoulos, S. Acharya, LSU, **Award date 5/95, Implementation date 6/1/95.**

Topic: Carbon Cycling and Hydrology in a Shallow Coastal Estuary

Environmental Protection Agency-EPSCoR, "**The Fate of Particle-reactive Contaminants in Shallow Coastal Environments**," \$279,484, Two years, B. McKee, R. Powell, S. Mitra, G. Booth and R. Miller, **Implementation Date AY 00-02.**

NASA (Graduate Student Researchers Program), "**Dynamic Particle Processes and Biogeochemical Material Flux in River-Dominated Ocean Margins.**" \$66,000, Three years, F. Clark, **Implementation Date AY 98-02.**

Office of Naval Research "**River-Ocean Interactions: Phase 1: The Processing and fates of Nutrients and Organic Carbon from the Mississippi River**," \$577,802, Two years, B. McKee, T. Bianchi, G. Booth, M. Dagg, R. Miller and R. Powell, **Implementation Date AY 98-01.**

Department of Defense "**Evaluating the Effects of Seasonal Sediment Storage, Diagenesis, and Remobilization on the Fate of Sediment Contaminants in the Lower Mississippi River**," \$340,516, Two years, B. McKee, T. Bianchi and S. Mitra, **Implementation Date AY 98-00.**

NASA (Graduate Student Researchers Program), "**Particulate Flux in Marshes of the Barataria Bay Drainage System**," \$66,000., Three years, R. J. Rovasek, **Implementation Date AY 95-96.**

NASA (Graduate Student Researchers Program), "**Transport of Dissolved Organic Carbon Using Remote Sensing**," \$66,000., Three years, D. Muirhead, **Implementation Date AY 95-96.**

Section I: Patents Granted

Topic: Louisiana Balloon-Borne Experiment Cluster

M. L. Cherry and S. B. Ellison, "Bi-Directional, Fast Timing, Charge Coupled Device," U. S. Patent Number 5,693,968, awarded 12/2/97.

Section II: Other Publications

Topic: Louisiana Balloon-Borne Experiment Cluster

J.G. Stacy and W.T. Vestrand, "Gamma Ray Astronomy", *Encyclopedia of Physical Science and Technology*, 3rd Edition 6, 397, (2002).

M.L. Cherry and J.P. Wefel, "Transition Radiation Detectors and Cosmic Rays at the Knee", *Proc. Transition Radiation Detectors for the Third Millenium*, Bari, to be published, (2002).

M.L. Cherry and G. Case, "X-Ray Transition Radiation from Extremely High Energy Particles", *Proc. Transition Radiation Detectors for the Third Millennium*, Bari, to be published, (2002).

C. Spiering et al., "Science Potential of the Ice Cube Detector", *Proc. 26th Intl. Cosmic Ray Conf.*, Hamburg, 1245, (2001).

A. Goldschmidt et al., "The Ice Cube Detector", *Proc. 26th Intl. Cosmic Ray Conf.*, Hamburg, 1237, (2001).

G.L. Case, M.L. Cherry, T.G. Guzik, J. Isbert, and J.P. Wefel, "X-Ray Transition Radiation from High Energy Particles", *Proc. 27th Intl. Cosmic Ray Conf.*, Hamburg **6**, 2251, (2001).

D. Band, M. Cherry, J. Stacy, T. Guzik, S. Kappadath, J. Buckley, P. Hink, J. Macri, M. McConnell, J. Ryan, and J. Matteson, "Progress on MARGIE, a Gamma Ray Burst Ultra-Long Duration Balloon Mission", *Proc. 2nd Workshop on Gamma Ray Bursts in the Afterglow Era*, Rome, to be published, (2001).

S.A. Naqvi et al., "Performance of the Advanced Thin Ionization Calorimeter (ATIC), *American Physical Soc. Mtg.*, Washington, Bull. APS **46**, 2, (2001).

E.S. Seo et al., "First Flight of the Advanced Thin Ionization Calorimeter (ATIC) Balloon Experiment, *American Physical Soc. Mtg.*, Washington, Bull. APS **46**, 2, (2001).

D. L. Band, M.L. Cherry, J.H. Buckley, T. Guzik, P.L. Hink, J.R. Macri, J.L. Matteson, M.L. McConnell, T.J. O'Neill, J.M. Ryan, J.G. Stacy, A.D. Zych, "MARGIE: A Gamma Ray Burst Ultra-Long Duration Balloon Mission," *Proc. 4th Gamma Ray Burst Symposium*, Huntsville, to be published, (2000).

J. Adams et al., "Simulation of the Ion Interactions for the ATIC Experiment," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **1**, 17 (1999).

T.G. Guzik et al., "The Advanced Thin Ionization Calorimeter (ATIC) for Studies of High Energy Cosmic Rays," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **5**, 9, (1999).

J. Adams et al., "On the Detection and Identification of Cosmic Gamma-rays in a Cosmic Ray Detector," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **5**, 37, (1999).

J. Adams et al., "On the Identification of High Energy Cosmic Ray Electrons in the Advanced Thin Ionization Calorimeter (ATIC)," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **5**, 41, (1999).

J. Adams et al., "Silicon Matrix Detector for ATIC," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **5**, 76, (1999).

J. Adams et al., "Data Processing and Event Reconstruction for the ATIC Balloon Payload," *Proc. 26th Intl. Cosmic Ray Conf.*, Salt Lake City **5**, 453, (1999).

T. G. Guzik, et al., "A Telescope Observatory for Education and Public Outreach Controlled through the World Wide Web," *Astronomical Telescopes and Instrumentation, SPIE*, (1998).

B. S. Nilsen, K. Asakimori, T. H. Burnett, M. L. Cherry, K. Chevli, M. J. Christl, S. Dake, J. H. Derrickson, W. F. Fountain, M. Fuki, J. C. Gregory, T. Hayashi, A. Iyono, J. Iwai, J. Johnson, M. Kobayashi, J. Lord, O. Miramura, K. H. Moon, H. Oda, T. Ogata, E. D. Olson, T. A. Parnell, F. E. Roberts, K. Sengupta, T. Shiina, S. C. Strausz, T. Sugitate, Y. Takahashi, T. Tominaga, J. W. Watts, J. P. Wefel, B. Wilczynska, H. Wilczynski, R. J. Wilkes, W. Wolter, H. Yokomi, E. Zager, "New Results on Cosmic Ray H and He Composition from the JACEE Collaboration," *Proc. 18th Texas Symp. on Relativistic Astrophysics and Cosmology* (Chicago), ed. A. V. Olinto, J. A. Frieman and D. N. Schramm (Singapore, 1998, World Scientific), pp. 438-440, (1998).

M. Abdelguerfi, "Towards Virtual Word Reconstruction Using the Modeling and Simulation Extended Vector Product (MSEVP), *IASTED International Conference on Modeling, Simulation and Optimization*, paper 242-091 (1997).

J. Isbert, M. L. Cherry, T. G. Guzik, J. P. Wefel, E. Diehl, D. Müller, S. Swordy, W. R. Binns, P. Hink, M. H. Israel, T. L. Wilson, J. H. Adams, Jr., C. Schwarz, R. H. Kroeger, E-S. Seo, F. McDonald, R. A. Mewaldt, M. E. Wiedenbeck, G. Tarle, S. Torii, "ACCESS - Advanced Cosmic Ray Composition Experiment for the Space Station," *Proc. 25th Intl. Cosmic Ray Conference*, (Durban), **5**, 57, (1997).

H. Wilczynski, M. L. Cherry, A. Dabrowska, P. Deines-Jones, R. Holynski, D. Kudzia, A. Olszewski, B. S. Nilsen, K. Sengupta, M. Szarska, A. Trzupek, C. J. Waddington, J. P. Wefel, B. Wilczynska, W. Wolter, B. Wosiek, and K. Wozniak, "Measurement of Charges of Heavy Ions Using a CCD Camera," *Proc. 25th Intl. Cosmic Ray Conference*, (Durban), **7**, 285, (1997).

W. Wolter, M. L. Cherry, A. Dabrowska, P. Deines-Jones, R. Holynski, D. Kudzia, A. Olszewski, B. S. Nilsen, M. Szarska, A. Trzupek, C. J. Waddington, J. P. Wefel, B. Wilczynska, H. Wilczynski, B. Wosiek, and K. Wozniak, "Fragmentation of the Projectile Pb Nucleus in Pb+Pb Interactions at 158 GeV/c," *Proc. 25th Intl. Cosmic Ray Conference*, (Durban), **6**, 5, (1997).

P. Deines-Jones, M. L. Cherry, A. Dabrowska, J. Dugas, R. Holynski, W. V. Jones, D. Kudzia, B. S. Nilsen, A. Olszewski, M. Szarska, A. Trzupek, C. J. Waddington, J. P. Wefel, B. Wilczynska, H. Wilczynski, W. Wolter, B. Wosiek, and K. Wozniak, "Charged Particle Production in Pb-Pb at 158 GeV/nucleon," *Proc. 25th Intl. Cosmic Ray Conference*, (Durban), **6**, 9, (1997).

O. Miyamura, T. Sugitate, T. Tominaga, T. Kohno, I. Tanihata, S. Yanagita, H. Yokomi, M. Kobayashi, M. Fuki, K. Asakimori, A. Iyono, T. Kajino, T. Yuda, S. Kuramata, M. Ichimura, S. Kasai, Y. Takahashi, J.C. Gregory, M. L. Cherry, J. P. Wefel, T.A. Parnell, R.J. Wilkes, H

Wilczynski, "Emulsion Chamber Experiments for the International Space Station," *Proc. 25th Intl. Cosmic Ray Conference*, (Durban), **5**, 17, (1997).

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